Ain Shams University *Faculty of Engineering* *Department of Design and Production Engineering* **Fourth Year Production Engineering Students**		
Operations Research	***Final Exam***	**3 Hrs**
Answer all questions. Neat answers are appreciated. Start the answer always in a new page.		**January 2011**

1. Solve the following LP model graphically. Draw to appropriate scale:

   Maximize $Z = 6X + 2Y + 60$

   Subject to $3X + Y \leq 48$

   $3X + 4Y \leq 120$

   $3X + Y \geq 36$; and $X \geq 0, Y \geq 0$

   Show in your answer:

   a) The feasible solution space.

   b) The basic solution points, and the optimum values of X and Y.

   c) The value of Z at each basic solution point and the optimum value of Z.

2. Use the simplex method with big-M to verify the solution obtained in problem number 1 for the optimum values of X, Y and Z.

3. An operational manager wants to assign trucks to delivery routes to minimize the total cost. The cost data (in 1000L.E.) based on the distance is shown in the given table below. There is a limit on the maximum weight allowed to utilize each route. Find the optimal assignment and the associated cost.

			Route				
			A	B	C	D	E
		Allowed weight / Truck Weight	3	4	3	4	3
Truck	1	1 tonne	4	5	9	8	7
	2	1 tonne	6	4	8	3	5
	3	1 tonne	7	3	5	4	6
	4	4 tonne	5	10	8	10	8
	5	2 tonne	6	5	3	4	9

4. Solve the following IP problem

Maximize $Z = 3X_1 + 2X_2$

Subject to

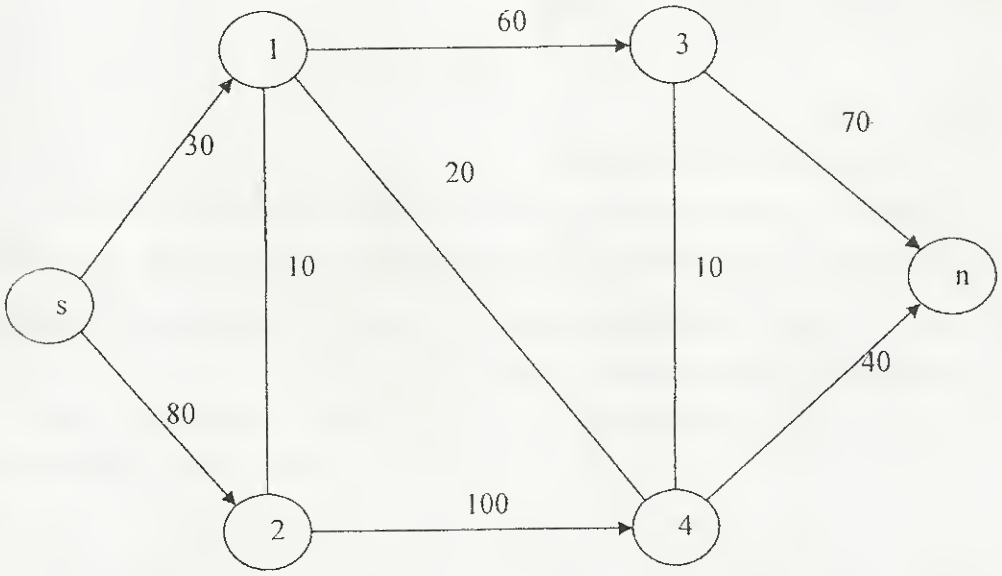
$X_1 \leq 2$

$X_2 \leq 2$

$X_1 + X_2 \leq 3.5$

$X_1, X_2 \geq 0$ and integer

5. Consider a street network as shown below:



Given the capacity on the arcs, find the maximal flow in the network from (s) to (n) and the flow in each arc.

6. For an undirected network with 8 nodes and 13 arcs, the distance in km between nodes *i* and *j*, denoted as d_{ij}, is as follows: d_{12}=5, d_{13}=1, d_{14}=7, d_{23}=4, d_{34}=2, d_{35}=10, d_{36}=9, d_{46}=3, d_{56}=3, d_{57}=4, d_{67}=9, d_{68}=8, and d_{78}=6. Find the shortest distance and the shortest path between nodes 1 and 8.

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
DESIGN & PRODUCTION ENGINEERING DEPARTMENT
4th Year, Production Section

1st Semester, 2009-1010, January 2010 — *Time: 3.00 Hrs*

[MDP 493 Elective Course (3)] (MDP 455 Operations Research)

The Exam Consists of **Seven** Questions in **Four** Pages.

Answer *Six only* from the Following Seven Questions:

(12 Marks)

Question (1)

A company supplying three types of parts (A, B, C) to an automatic manufacturing company, purchases castings of the three parts from a nearby foundry and performs three types of operations (cutting, drilling, and polishing) before selling these parts to the automatic manufacturing company. Important information is provided in the following Table:

Machine	Capacity Units/hour A	Capacity Units/hour B	Capacity Units/hour C	Cost (L.E./hour)
Cutting	20	60	25	150
Drilling	40	20	40	100
Polishing	50	50	20	200

The cost of the castings is L.E. 120, 200, and 400 for A, B, and C, respectively. The selling price of these parts is L.E. 200, 350, and 500 for A, B, and C, respectively. All the parts that are processed by the company can be sold.

Formulate a model that can be used to determine the quantity of the various parts that the company should process for selling in order to maximize its profits.

(12 Marks)

Question (2)

Solve the following linear programming model:

Minimize $Z = 6X1 + 3X2 + 4X3$

Subject to:

$$X1 + 6X2 + X3 = 10$$
$$2X1 + 3X2 + X3 = 15$$

$$X1 \geq 0 \ , \ X2 \geq 0 \ , \ X3 \geq 0$$

Question (3)

(12 Marks)

A company has four different locations (A, B, C, D) in the country and four sales agencies (1, 2, 3, 4) in four other locations in the country. The cost of production, the sale price, the shipping costs (shown in the cells of the matrix), the monthly capacities, and the monthly requirements are given below:

Factory \ Sales Agencies	1	2	3	4	Capacity (units)	Cost of Production (L.E./unit)
A	7	5	6	2	10	10
B	3	5	4	2	15	15
C	4	6	4	5	20	16
D	8	7	6	5	15	15
Monthly Requirements	8	12	18	22		
Selling Price (L.E./unit)	20	22	25	18		

Find the monthly production and distribution schedule which will maximize profits.

Question (4)

(12 Marks)

The Captain of a cricket team has to allot five middle batting positions to five batsmen. The average runs scored by each batsman at these positions are as follows:

		Batting Positions				
		I	II	III	IV	V
Batsman	P	40	40	35	25	50
	Q	42	30	16	25	27
	R	50	48	40	60	50
	S	20	19	20	18	25
	T	58	60	59	55	53

a) Find the assignment of batsmen to positions which would give maximum number of runs.

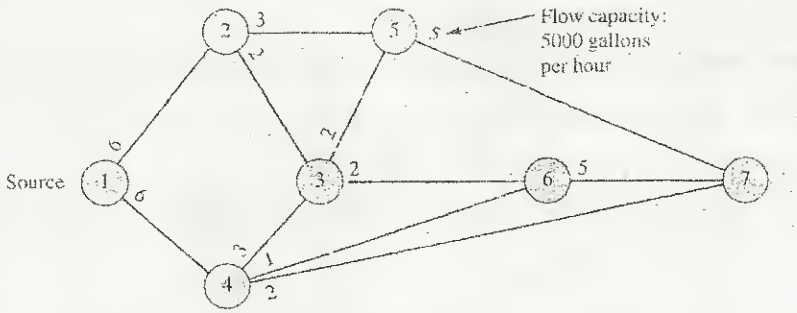
b) If another batsman U with the following average runs in batting positions as given below is added to the team, should he be included to play in the team? If so, who will be replaced by whom?

Batting positions	I	II	III	IV	V
Average runs	45	52	38	50	49

Question (5)

(12 Marks)

An oil company owns a pipeline network that is used to convey oil from its source to several storage locations. A portion of the network is as follows:



Due to varying pipe sizes, the flow capacities also vary. By selectively opening and closing sections of the pipeline network, the firm can supply any of the storage locations.

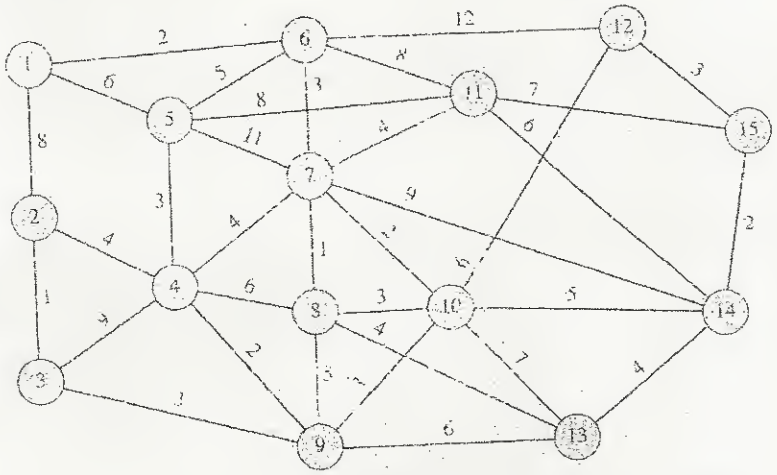
a) If the firm wants to supply storage location 7 and fully utilize the system capacity, how long will it take to satisfy a location 7 demand of 100 000 gallons? What is the maximal flow for this pipeline system?

b) If a break occurs on line 2-3 and it is closed down, what is the maximal flow for the system? How long will it take to transmit 100 000 gallons to location 7?

Question (6)

(12 Marks)

A city recently purchased land for a new park, and park planners have identified the ideal locations for the lodge, cabins, picnic groves, boat dock, and scenic points of interest. These locations are represented by the nodes of the following network. The arcs of the network represent possible road alternatives in the park. If the park designers want to minimize the total road miles that must be constructed in the park and still permit access to all facilities (nodes), which road alternatives should be constructed?



Question (X)

(12 Marks)

The men's department of a large store employs one tailor for customer fittings. The number of customers requiring fittings appears to follow a Poisson distribution with mean arrival rate 24 per hour. Customers are fitted on a first-come, first-served basis. The time it takes to fit a customer appears to be exponentially distributed, with a mean of 2 min.

a- What is the average number of customers in the fitting room?

b- How much time should a customer expect to spend in the fitting room?

c- What percentage of the time is the tailor idle?

d- Would it be better for the store to have a second tailor? Justify your answer.

Ain Shams University
Faculty of Engineering
Design & Production Eng. Dept

Final Exam, January 2009
Time allowed 3 hr.
4th year Production Engineering

Operations Research

The following exam consists of 6 questions in 3 pages
Attempt the following questions:

Question 1:
A company that operates 10 hours a day manufactures each of two products on three sequential processes. The following table summarizes the data of the problem:

	Minutes per unit			
Product	Process 1	process 2	process 3	Unit profit
1	10	6	8	$2
2	5	20	10	$3

(a) Determine the optimum mix of the two products
(b) Suppose that the three processes are being considered for expansion, and you are required to prioritize them. Devise a logical way for achieving this goal. (use sensitivity analysis for that purpose)

Question 2:
A company has factories A, B, and C, which supply warehouses D, E, F, and G. Monthly factory capacities are 300, 400, and 500 respectively. Monthly warehouse requirements are 200, 240, 280 and 340 respectively. Unit shipping costs in L.E. are as follows:

		TO			
FROM		D	E	F	G
	A	7	9	9	6
	B	6	10	12	8
	C	9	8	10	14

Formulate the problem as a transportation problem, and then determine the optimum distribution for this company to minimize shipping costs using VAM then MODI. (Draw a separate tableau for each step)

Question 3:
An Aerospace agency has three projects to be performed in the next five years. The company wants to assign each project to different contractor. Four contractors submitted their offers as follows:

	Contractors' bids in million of $		
Contractor	Project 1	Project 2	Project 3
A	5	9	4
B	2	7	9
C	10	6	13
D	4	7	7

a) Which bids should the agency accept in order to fulfill the contract terms at the least cost?
b) If the agency doesn't want contractor A to be awarded project 3, how the problem formulation could be altered.

Question 4:

a) Formulate the problem in LP standard form and construct the first tableau and choose the first pivot value. (don't solve the problem)

Maximize $Z = -2X_1 + X_2 - 4X_3 + 3X_4$

subject to

$$X_1 + X_2 + 3X_3 + 2X_4 \leq 4$$
$$X_1 - X_3 + X_4 \geq -1$$
$$2X_1 + X_2 \leq 2$$
$$2X_1 + 2X_2 + X_3 + 2X_4 = 4$$

$X_2, X_3, X_4 \geq 0$ $\quad$ X_1 unrestricted

b) Minimize $Z = 2X1 + X2 + 3X3$

Subject to

$$5X_1 + 2X_2 + 7X_3 = 420$$
$$3X_1 + 2X_2 + 5X_3 \geq 280$$

and X_1, X_2 and $X_3 \geq 0$

Using the *M-Method* Solve by the simplex method

Question 5:

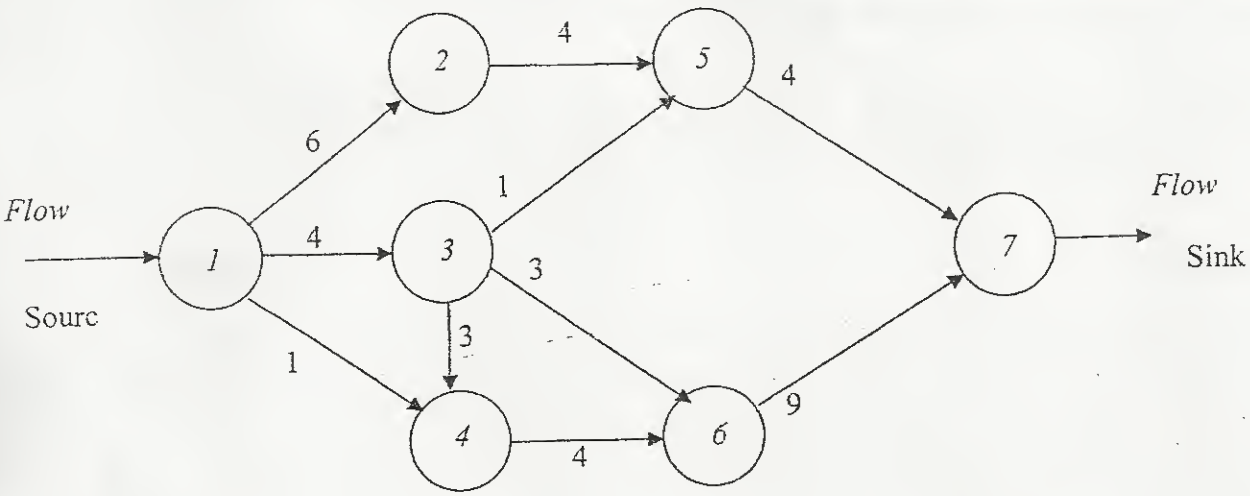
A logging company will soon begin logging eight groves of trees in the same general area. Therefore, it must develop a system of direct roads that makes each grove accessible from every other grove. The distance (in km) between every pair of groves is as follows:

		Distance between pairs of groves							
		1	2	3	4	5	6	7	8
Grove	1	-	1.3	2.1	0.9	0.7	1.8	2.0	1.5
	2	1.3	-	0.9	1.8	1.2	2.6	2.3	1.1
	3	2.1	0.9	-	2.6	1.7	2.5	1.9	1.0
	4	0.9	1.8	2.6	-	0.7	1.6	1.5	0.9
	5	0.7	1.2	1.7	0.7	-	0.9	1.1	0.8
	6	1.8	2.6	2.5	1.6	0.9	-	0.6	1.0
	7	2.0	2.3	1.9	1.5	1.1	0.6	-	0.5
	8	1.5	1.1	1.0	0.9	0.8	1.0	0.5	-

Solve the problem the problem to determine between which pairs of groves the roads should be constructed to connect all groves with a minimum total length of road.

Question 6:

What is the maximum possible flow applying the **cut capacity** theory for network given below? Find the flow pattern giving the maximum flow from the supply node (the left most node) to the demand node (the right most node).



Answer *Five only* from the Following Six Questions:

Question (1)

(15 Marks)

The production editor for a certain Publishing Company has 1800 pages of manuscript that must be copyedited. Because of the short time frame involved, only two copyeditors are available: Editor1 and Editor2. Editor1 has 10 days available and Editor2 has 12 days available. Editor1 can process 100 pages of manuscript per day and Editor2 can process 150 pages of manuscript per day. The Publishing Company has developed an index used to measure the overall quality of a copyeditor on a scale from 1 (worst) to 10 (best). Editor1's quality rating is 9 and Editor2's quality rating is 6. In addition, Editor1 charges 3 L.E. per page of copyedited manuscript and Editor2 charges 2 L.E. per page. If a budget of 4800 L.E. has been allocated for copyediting, how many pages should be assigned to each copyeditor in order to complete the project with the highest possible quality?

Question (2)

(15 Marks)

Solve the following Linear Programming problem:

$$\text{Min } Z = 4x_1 + 5x_2 + x_3$$

Subject to :

$$4x_1 + 2x_3 \geq 20$$
$$1x_2 - 1x_3 \leq -8$$
$$1x_1 - 2x_2 = -5$$
$$2x_1 + 1x_2 + 1x_3 \leq 12$$
$$x_1, x_2, x_3 \geq 0$$

Question (3)

(15 Marks)

A Subcontractor has a one-year contract to supply motors for all refrigerators produced by a Refrigeration Company. The Company manufactures the refrigerators at four locations around the country: Location1, Location2, Location3, and Location4. Plans call for the following number (in thousands) of refrigerators to be produced at each location.

Location1	50
Location2	70
Location3	60
Location4	80

The Subcontractor has three plants that are capable of producing the motors. The plants and production capacities (in thousands) are:

Plant1	100
Plant2	100
Plant3	150

Because of varying production and transportation costs, the profit that the Subcontractor earns on each lot of 1000 units depends on which plant produced the lot and which destination it was shipped to. The following table gives the accounting department estimates of the profit in L.E. per unit (shipments will be made in lots of 1000 units).

	Shipped To			
Produced At	**Location1**	**Location2**	**Location3**	**Location4**
Plant1	7	11	8	13
Plant2	20	17	12	10
Plant3	8	18	13	16

With profit maximization as a criterion, the Subcontractor wants to determine how many motors should be produced at each plant and how many motors should be shipped from each plant to each destination.

Question (4)

(15 Marks)

A Cab Company has identified 10 primary pickup and drop locations for cab riders in a certain City. In an effort to minimize travel time and improve customer service and the utilization of the company's fleet of cabs, management would like the cab drivers to take the shortest route between locations whenever possible. Using the following network (Fig. 1) of roads and streets, what is the route a driver beginning at location 1 should take to reach location 10? The travel times in minutes are shown on the arcs of the network.

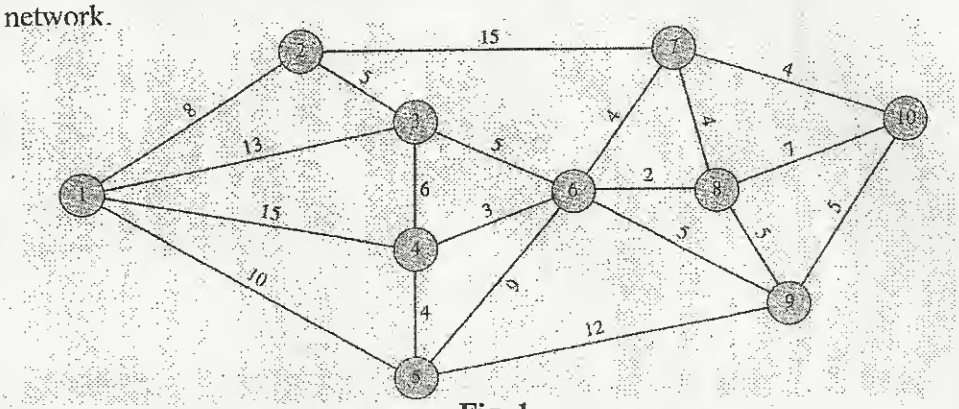


Fig. 1

Question (5)

(15 Marks)

An investor recently purchased land for a new leisure park, and park planners have identified the ideal locations for the lodge, cabins, picnic groves, boat dock, and scenic points of interest. These locations are represented by the nodes of the following network (Fig. 2). The arcs of the network represent possible road alternatives in the park. If the park designers want to minimize the total road miles that must be constructed in the park and still permit access to all facilities (nodes), which road alternatives should be constructed?

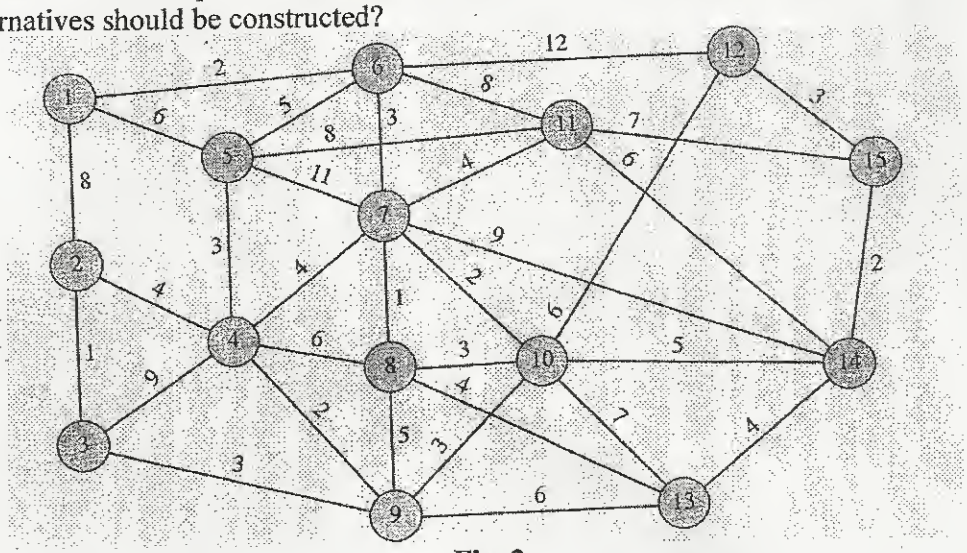


Fig. 2

Question (6)

(15 Marks)

An Oil Company owns a pipeline network that is used to convey oil from its source to several storage locations. A portion of the network is as follows (Fig. 3):

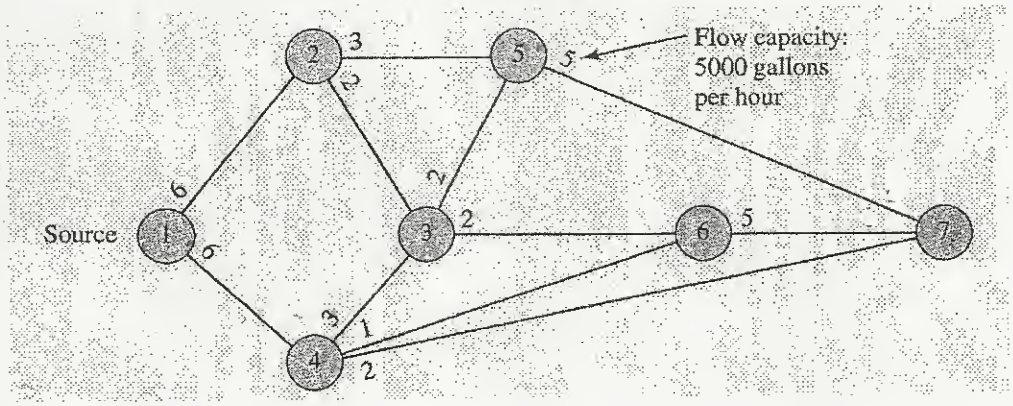


Fig. 3

Due to the varying pipe sizes, the flow capacities also vary. By selectively opening and closing sections of the pipeline network, the firm can supply any of the storage locations.

a. If the firm wants to supply storage location 7 and fully utilize the system capacity, how long will it take to satisfy a location 7 demand of 100,000 gallons? What is the maximal flow for this pipeline system?

b. If a break occurs on line 2-3 and it is closed down, what is the maximal flow for the system? How long will it take to transmit 100,000 gallons to location 7?

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
DESIGN & PRODUCTION ENGINEERING DEPARTMENT
4th Year, Production Section

1st Semester, 2006-2007, January 2007 — *Time: 3.00 Hrs*

[MDP 493 Elective Course (3)] (MDP 455 Operations Research]

The Exam Consists of Five Questions in Four Pages.

Answer the Following Questions:

Question (1)

A manufacturer produces three models, I, II, and III, of a certain product using raw materials A and B. The following table gives the data for the problem.

	Requirements per units			
Raw material	I	II	III	Availability
A	2	3	5	4000
B	4	2	7	6000
Minimum demand	200	200	150	
Profit per unit (L.E.)	30	20	50	

The labor time per unit of model I is twice that of model II and three times that of III. The entire labor force of the factory can produce the equivalent of 1500 units of model I. Market requirements specify the ratios 3 : 2 : 5 for the production of the three respective models.

Formulate the problem as a linear program, and find the optimal solution by simplex method.

Question (2)

A toy manufacturer has three warehouses (1, 2, and 3) that supply two stores (A, and B). Transportation costs as well as other data are shown in the following table:

From \ To		Store A	Store B	Supply (Units/week)
Warehouse	1	L.E 15	L.E 9	660
	2	10	7	340
	3	14	18	200
Demand Units/week		400	500	

The manufacturer is planning to open a new store. Three locations in Cairo are currently under consideration: Alatabah, Elzeitoun, and Elobour. Transportation costs for the locations are shown below.

From \ To		Store		
		Alatabah	Elzeitoun	Elobour
Warehouse	1	L.E 4	L.E 7	L.E 5
	2	11	6	5
	3	5	5	6

Each of the locations has a demand potential of 300 units per week. Which location would yield the lowest transportation cost for the system?

Question (3)

The mobile-phone company services six geographical areas. The satellite distances (in kilometers) among the six areas are given in Figure 1. The company needs to determine the most efficient message routes that should be established between each two areas in the network.

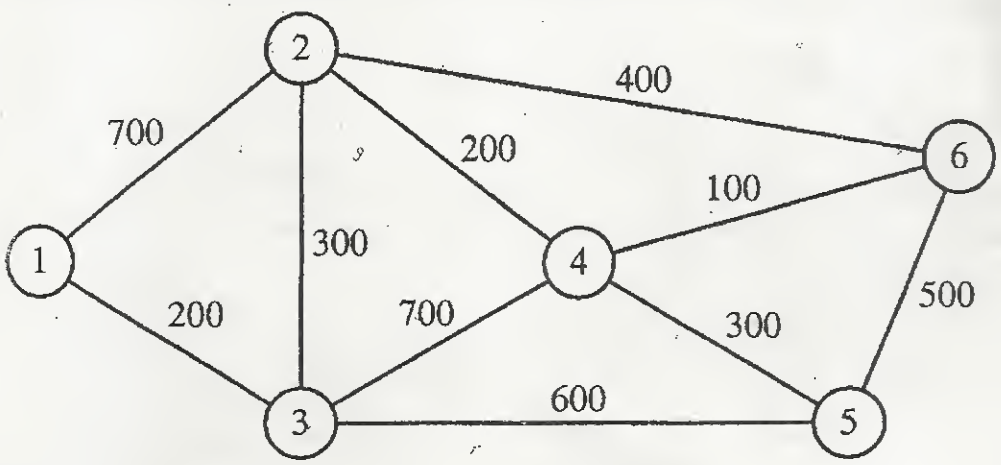


Fig. 1

Question (4)

Figure 2 gives the mileage of the feasible links connecting nine offshore natural gas wellheads with an inshore delivery point. Because the location of wellhead 1 is the closest to shore, it is equipped with sufficient pumping and storage capacity to pump the output of the remaining eight wells to the delivery point. Suppose that the wellheads can be divided into two groups depending on gas pressure: a high-pressure group that includes wells 2, 3, 4, and 6, and low-pressure group that include wells 5, 7, 8, and 9. Because of the pressure difference, it is not possible to link the wellheads of the two groups. At the same time, both groups must be connected to the delivery point through wellhead 1.

Determine the minimum pipeline network that links the wellheads to the delivery point.

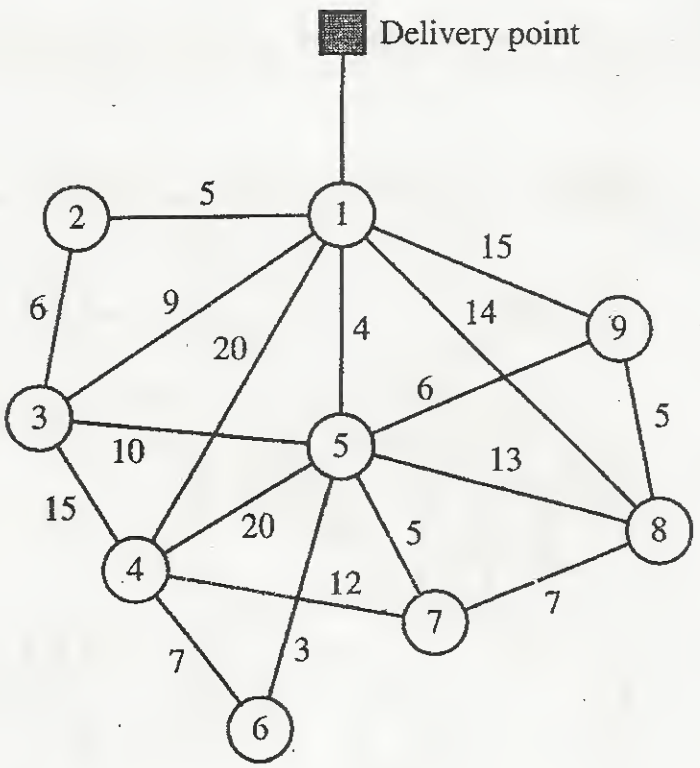


Fig. 2

Question (5)

Three refineries send a gasoline product to two distribution terminals through a pipeline network. Any demand that cannot be satisfied through the network is acquired from other sources. The pipeline network is served by three pumping stations as shown in Figure 3. The product flows in the network in the direction shown by the arrows. The capacity of each pipe segment (shown directly on the arcs) is in million bbl per day. Determine the following:

(a) The daily production at each refinery that matches the maximum capacity of the network.

(b) The daily demand at each terminal that matches the maximum capacity of the network.

(c) The daily capacity of each pump that matches the maximum capacity of the network.

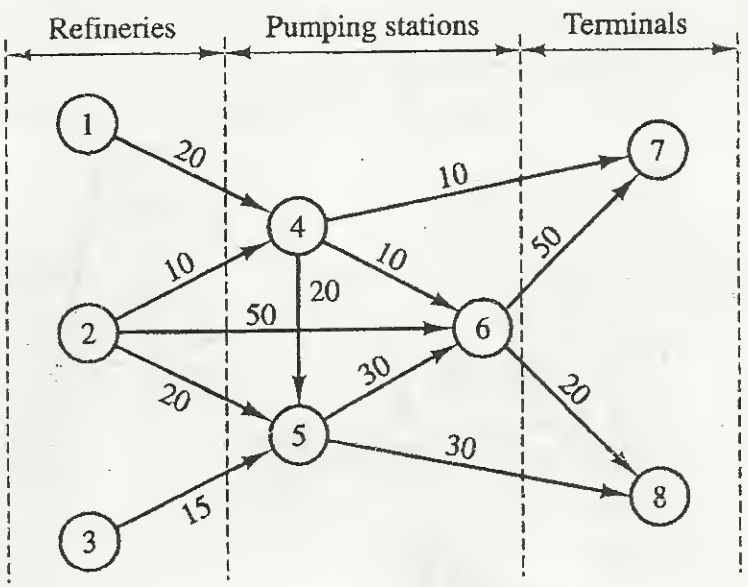


Fig. 3